Update on LeptoSusy sample studies

Simona

Outline

- Ntuple status
    - Updates
    - Event count
- Reconstructed Leptons
    - Slow muons, muons, electrons
- Slow Muons beta distribution
    - Trigger efficiency
- First ideas on possible analysis cuts
- Btgging
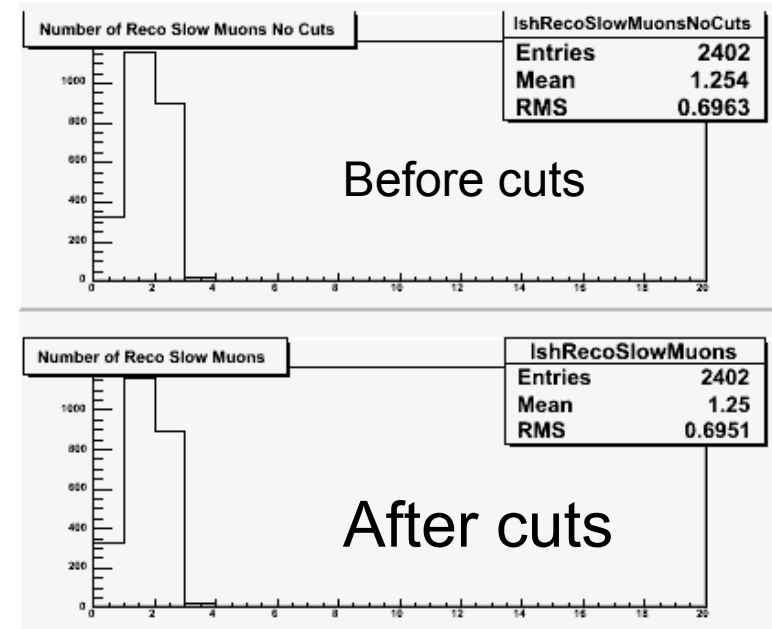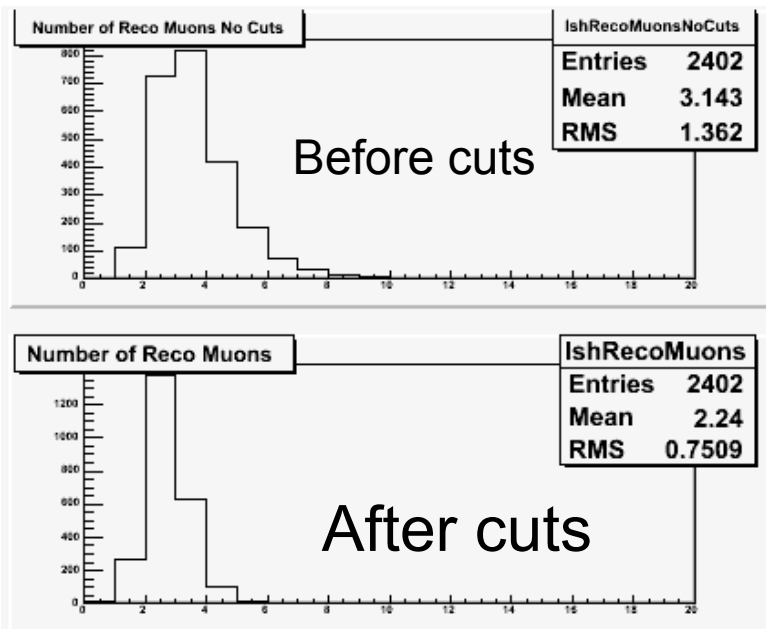   - Btag efficiency studies
- To Do List

Ntuple status

- All the energy/masses are now in GeV units!
- Added MuGirlLowBetaCollection for slow muons
- List of variables at:
  - http://ncdf70.fnal.gov:8001/atlas/JustSignalFull.h
- Ntuple at:
  - http://ncdf70.fnal.gov:8001/atlas/EvtNtuple.aan.justSignal.FullSimJorge.Allevt.AllJets.root
- Total number of events in ntuple: 9710
  - Number of events with 1 Higgs: 2204 ⎫
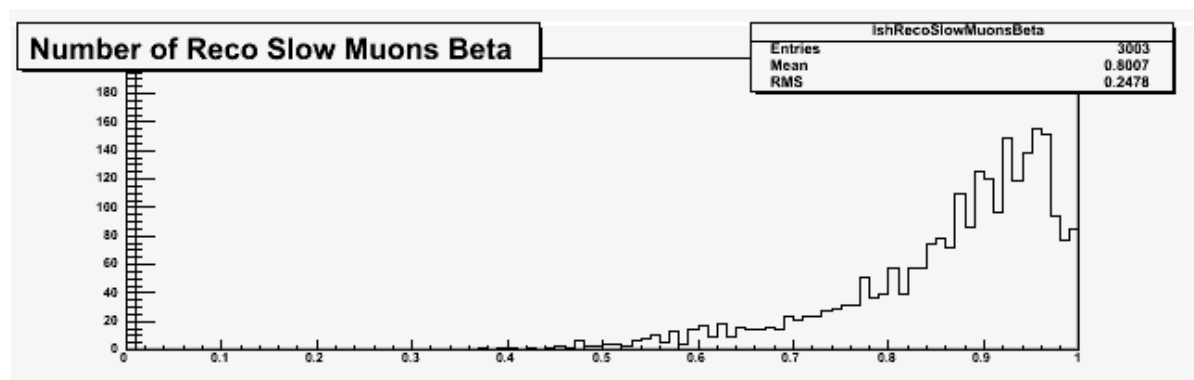 - Number of events with 2 Higgs: 198 ⎬ 2402
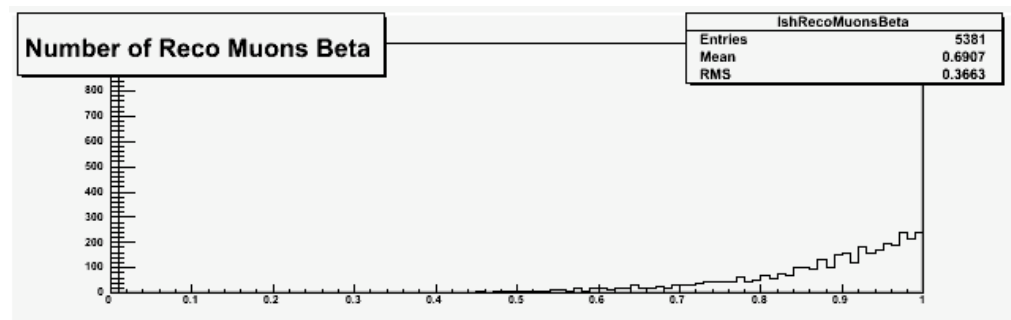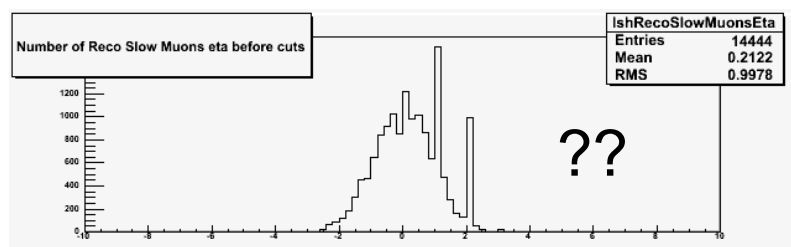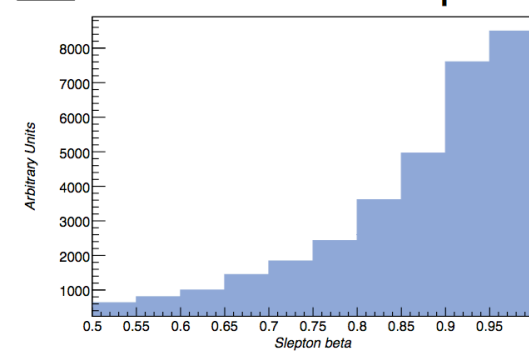 - Number of events w/o Higgs: 7308

Slow Muons

- Slow muon multiplicity as well as regular muons multiplicity after basic cuts:
  - PT > 25 GeV, $|\eta|$ < 2.5

Number of Reco Muons No Cuts	IshRecoMuonsNoCuts		
	Entries	2402
	Mean	3.143
	RMS	1.362

Before cuts

Number of Reco Muons	IshRecoMuons		
	Entries	2402
	Mean	2.24
	RMS	0.7509

After cuts

Number of Reco Slow Muons No Cuts	IshRecoSlowMuonsNoCuts		
	Entries	2402
	Mean	1.254
	RMS	0.6963

Before cuts

Number of Reco Slow Muons	IshRecoSlowMuons		
	Entries	2402
	Mean	1.25
	RMS	0.6951

After cuts

Beta of Muons and Slow Muons
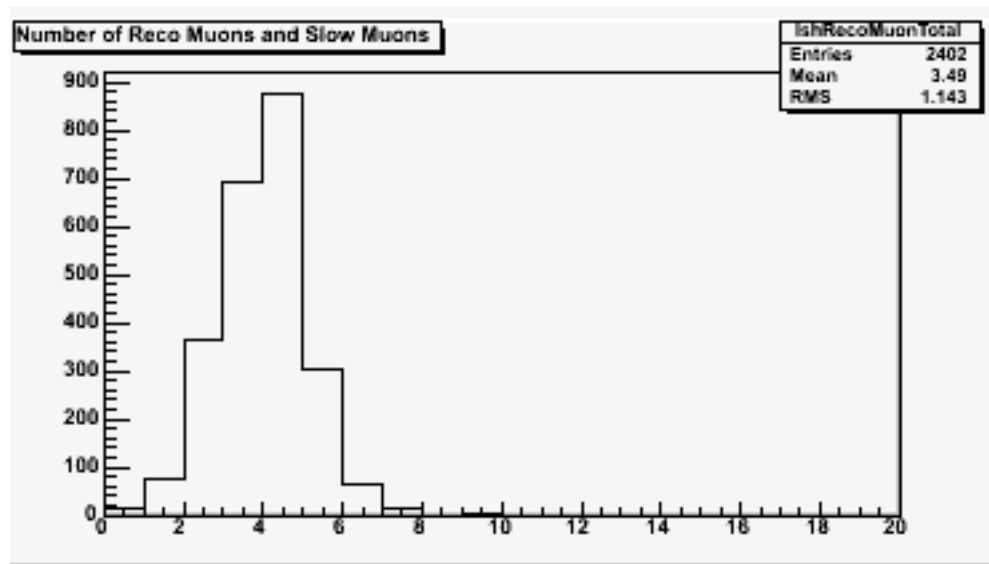

Strange eta distribution for slow muons before any cut…

Total Muon multiplicity

ET > 25
|η| < 2.5
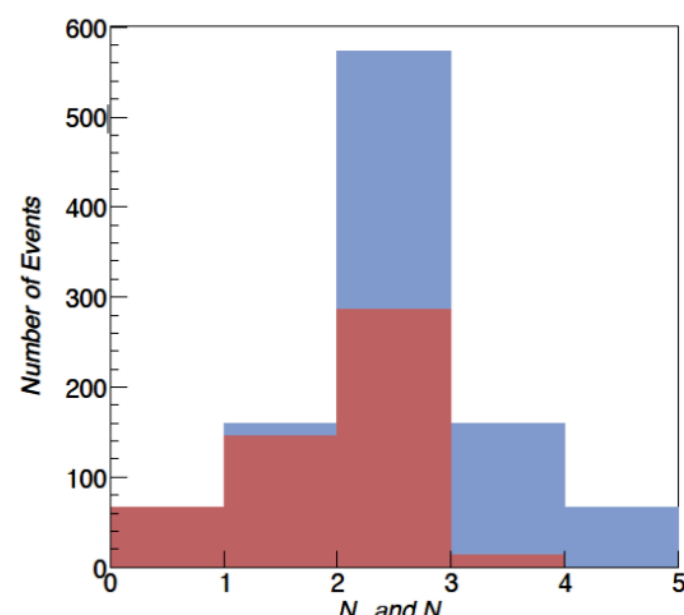
Too high…
Need cleanup?

Electron Multiplicity

ET> 25 GeV

$\eta < 2.5$
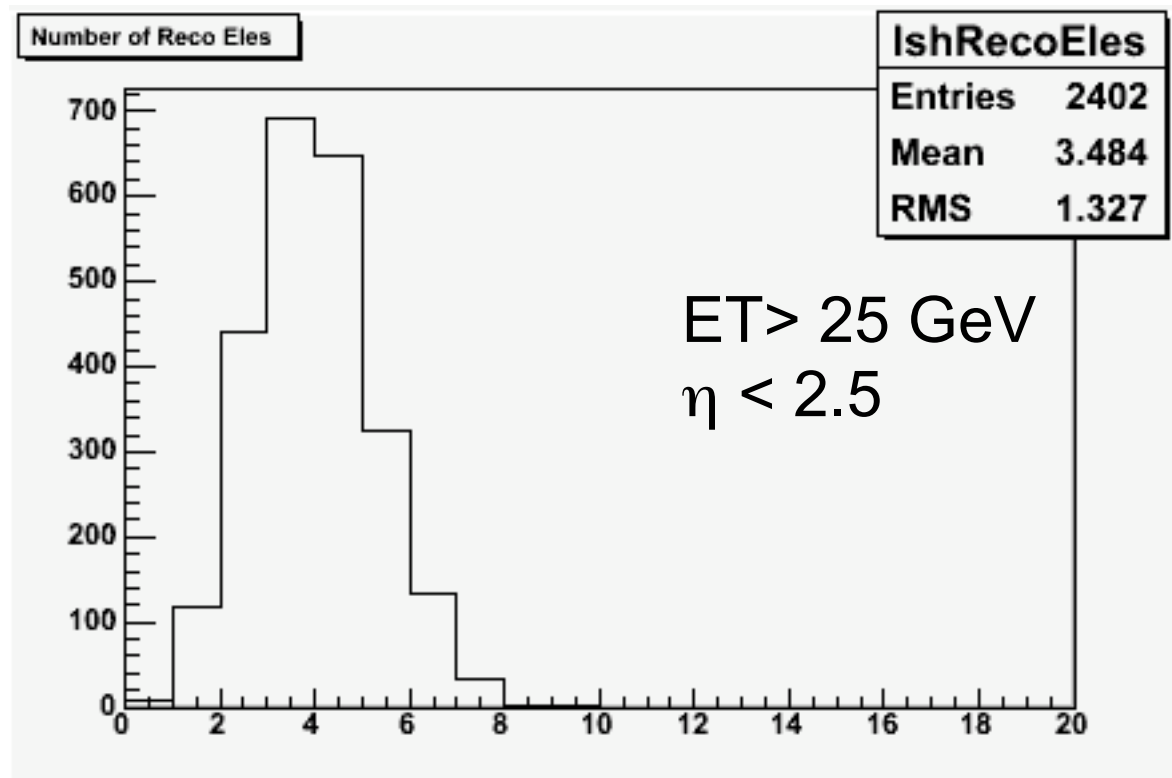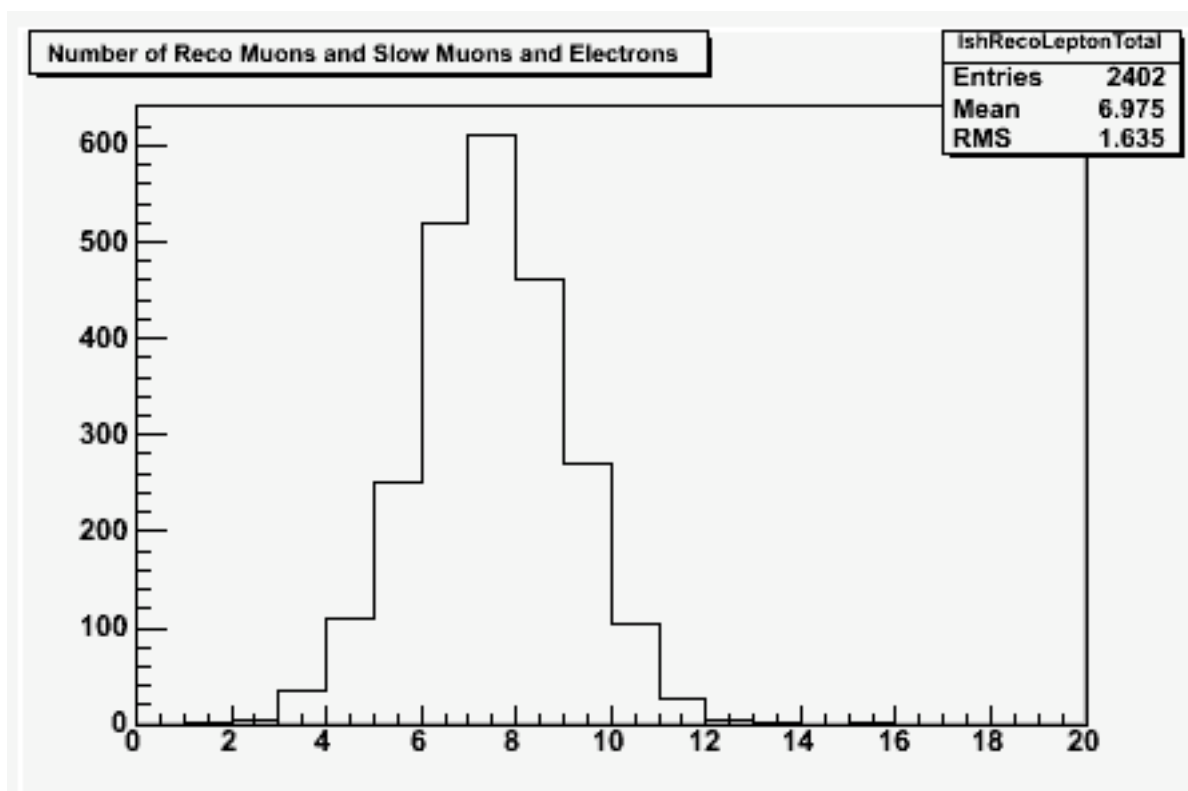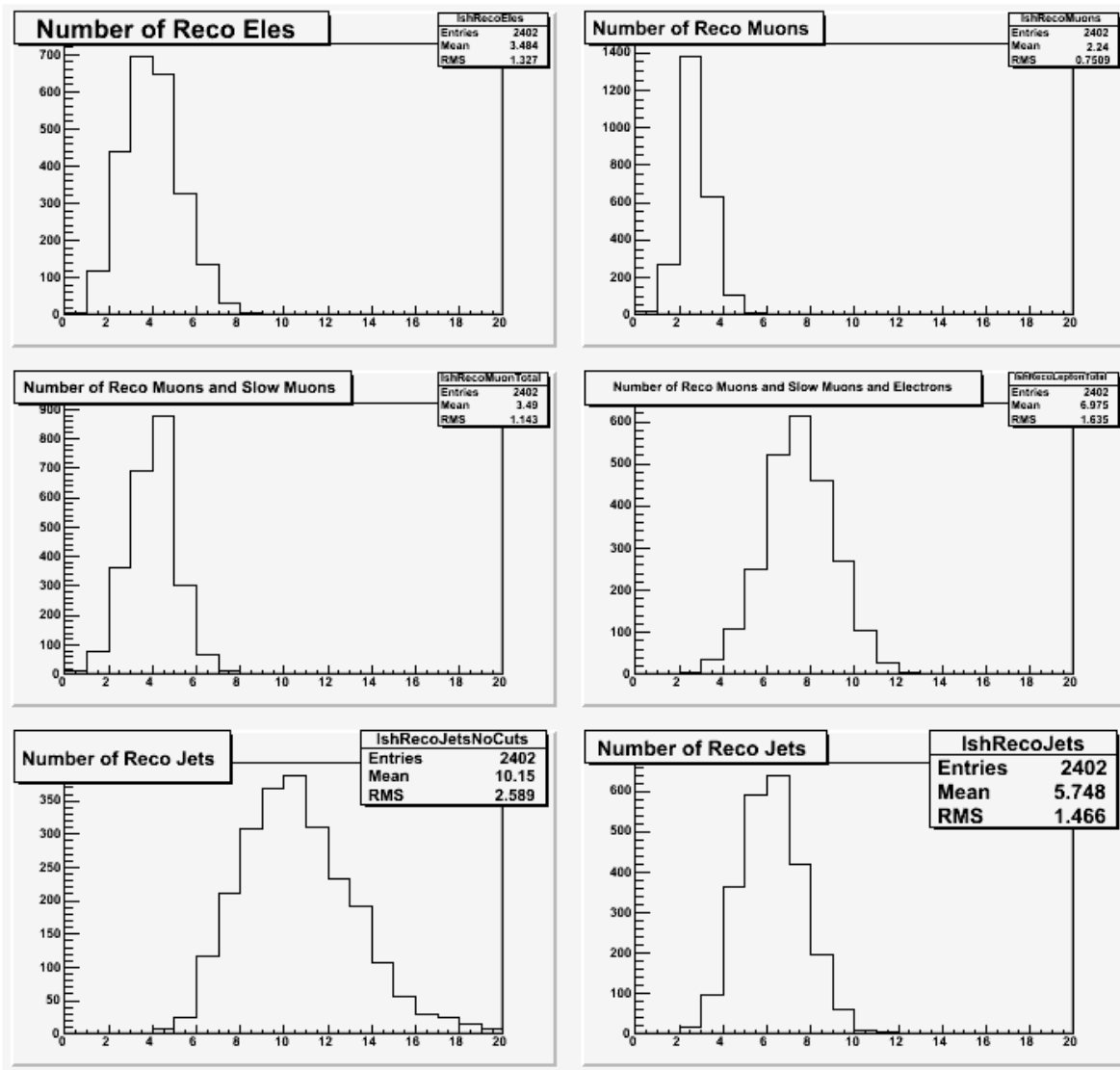
Too high:
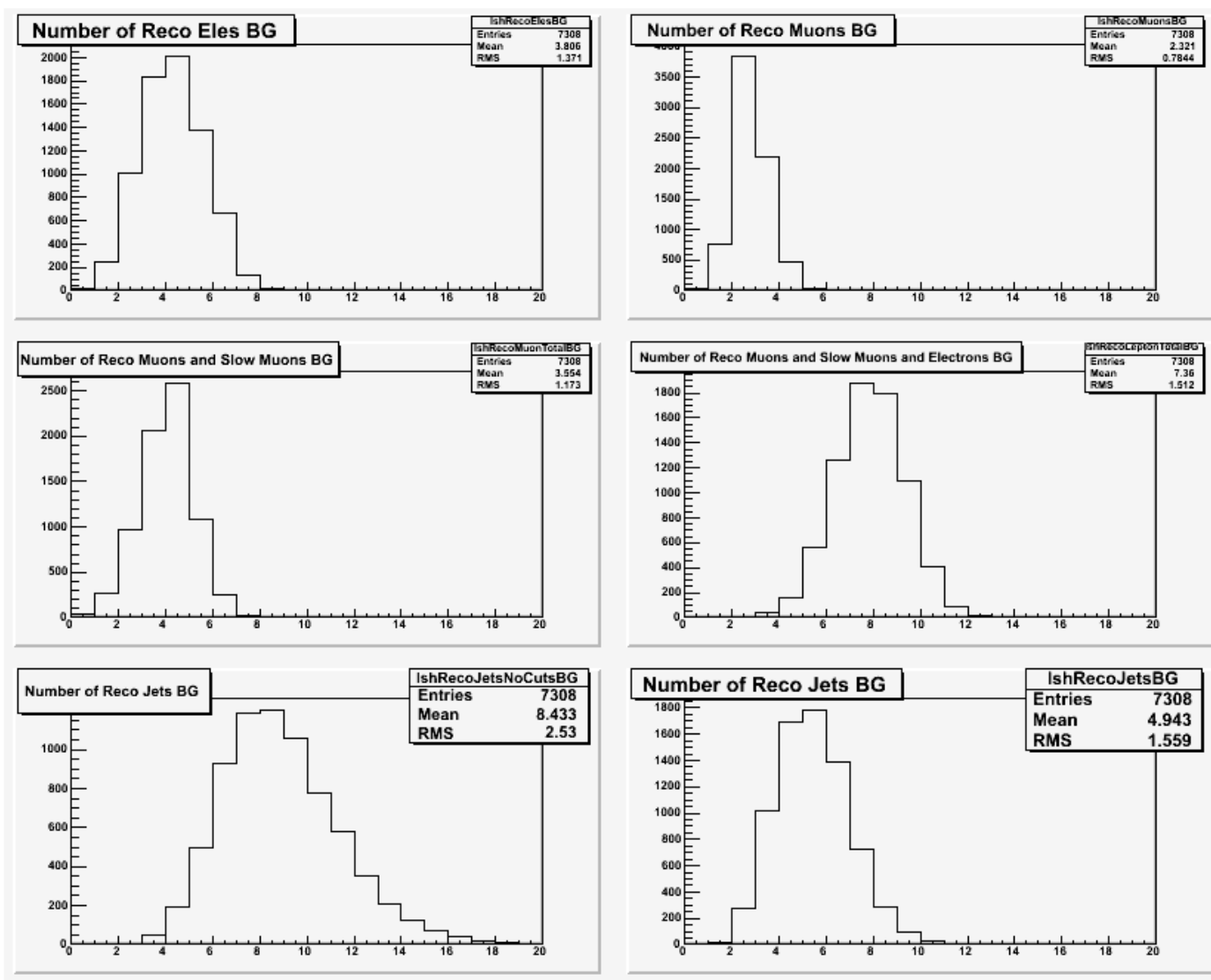Need cleanup?

Total lepton multiplicity

Too high!

Need to cleanup muons and electrons?

# Objects multiplicities: signal

Object multiplicities: background

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Trigger

- Let's assume that we use a trigger of a single slow muon with PT > 25 GeV and $\beta > 0.5$

- I selected such events in the signal-only and background samples:
  - Signal only:1910/2402 = 79.5%
  - Background:5670/7308 = 77.6%

- Need to to real Trigger Studies of course…

Preliminary Look at Trigger Info

- Looked at events passing L2_mu20_slow:
  - STAT Trigger Statistics on 9710 processed events
  - STAT Passed events for chain L2_mu20_slow 8735 (89.9588%)

passl2_mu20Slow

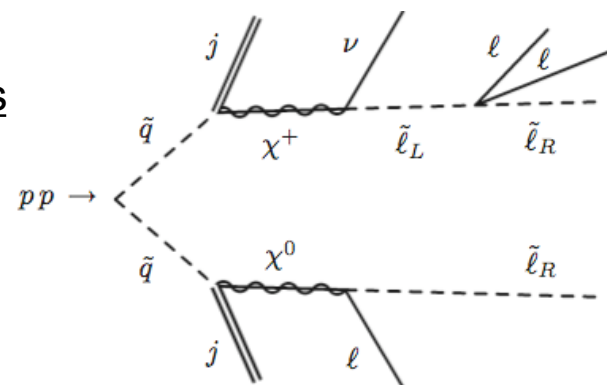| htemp	
Entries	9710
Mean	0.8996
RMS	0.3005
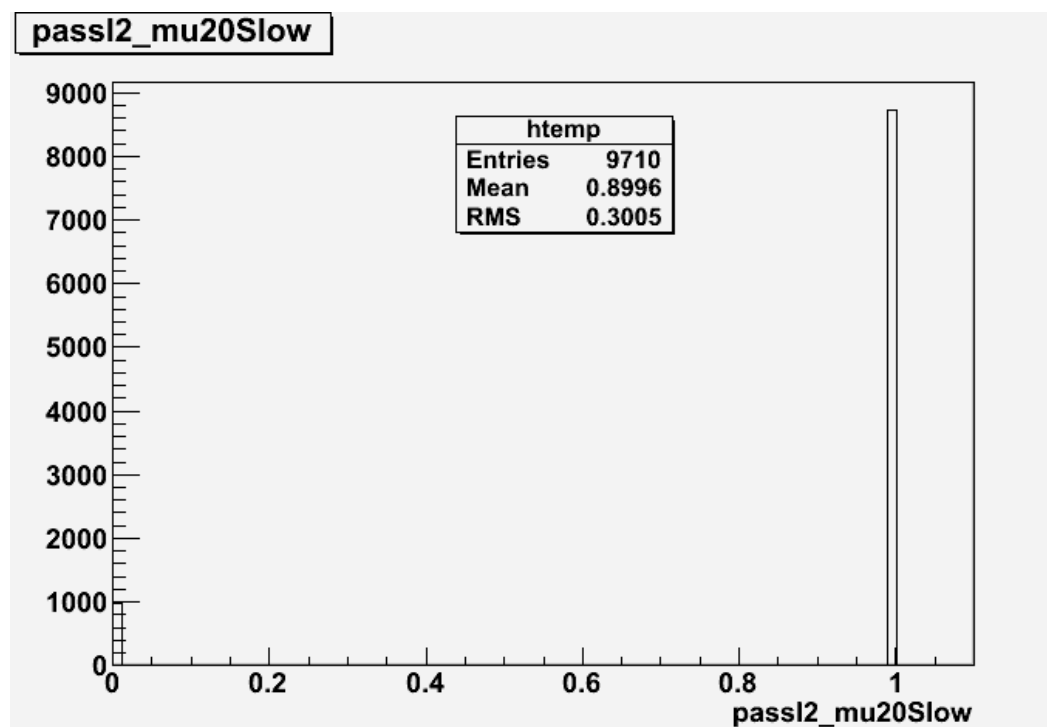
New variable in the nutple: passl2_mu20Slow

For efficiency curves need TrigMuGirl collection?
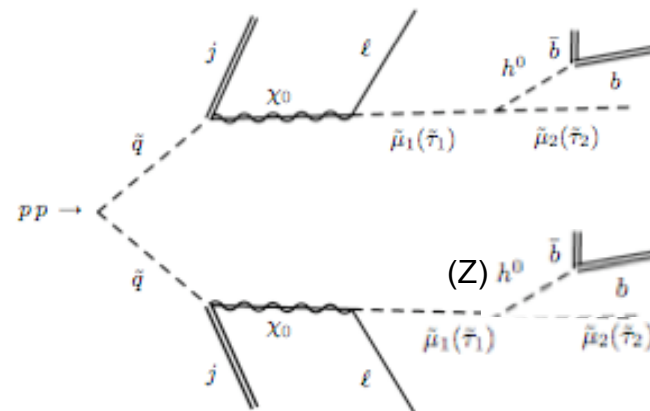
Signal and Background
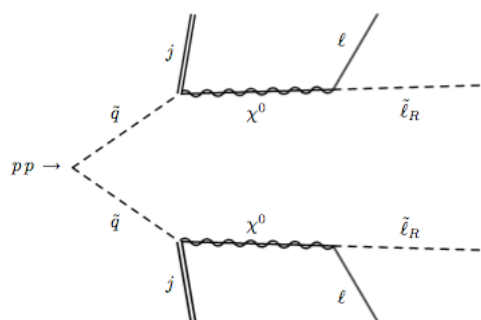
Final state topologies w/o Higgs
- -4 leptons (2 slow)
- -5 leptons (2 slow)
- -6 leptons (2 slow)
- -At least 2 jets

Final state topology with 1(2) Higgs
- -At least 4 leptons (2 slow)
- -At least 4 jets (sometime 6)
- -At least 2 btagged jets (sometime 4)

Strategy
trigger on slow leptons, ask for high jet multiplicity, require b-tag

A first run at event selection

- Tentative Selection:
  - 1 slow muon PT > 25, eta < 2.5
  - At least 4/5/6 jets with ET > 25 eta < 2.5
    - Several jet multiplicity cut to optimize S/B
    - Not much difference: here I'll show results for a 6 jets selection
  - Following Veronica lead in disregarding the first 2 jets….
  - Jet 3 and 4 with btag weight cut > -3,-2,-1,0
    - Several tag weights used to calculated tagging efficiency and Rejection factor
  - Dijet invariant mass cut ? (95 < m_{j3j4} < 200) ?

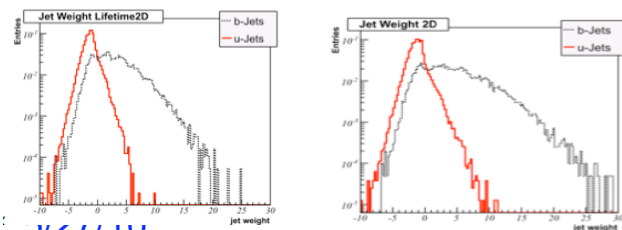- Calculated signal retention and background elimination (S/B)

Btag Weights (Reco) and Flavor (parton)
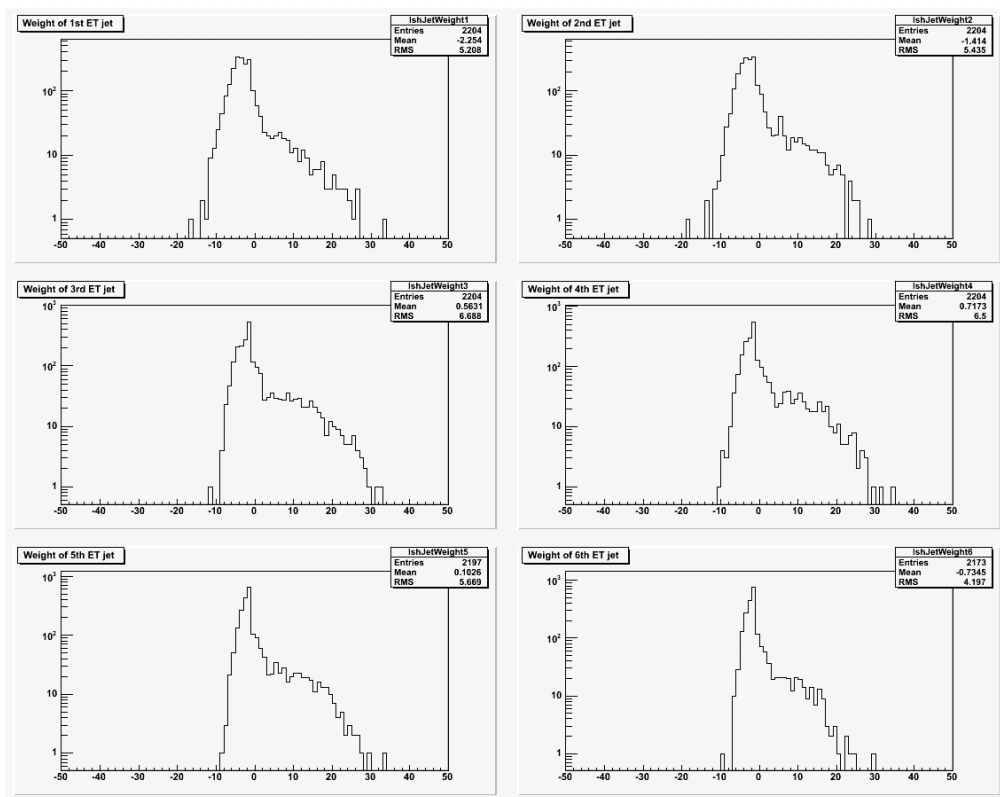
Weights tend to be peaked at < -3 for the first 2 jets
Consistent with the fact that the first 2 jets do not come from b's
Still the purity does not seem to indicate 3-6 jets as real b's (better than first 2, but…)
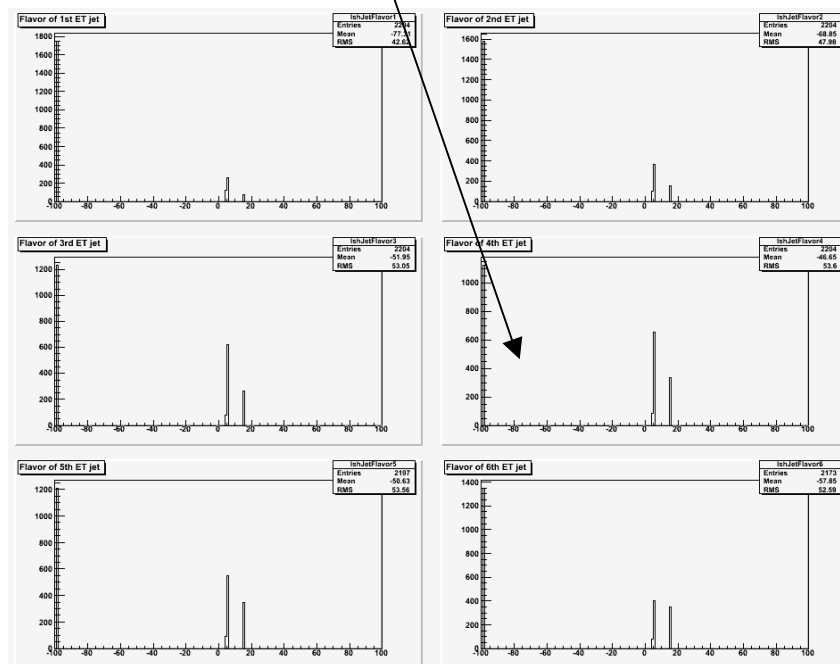

An example of weight from a different analysis

Weight Cut

- From the b-tagging official page:
  (https://twiki.cern.ch/twiki/bin/view/AtlasProtected/BTaggingFAQ#Choosing_a_cut_value)
  - By cutting on the b-tagging weight, you choose a working point defining a certain b-tagging efficiency `eps_b` and a level of rejection of light jets `R_u`. This choice is very analysis-dependent (mostly via jet pT/eta spectra), therefore the b-tagging group does not recommend a cut. In addition, the relation between the cut value and (`eps_b, R_u`) is not univoqual: it depends on the sample, the release and the b-tagging calibrations.

- I then proceed to do efficiency and rejection studies

Reference study with parton level info
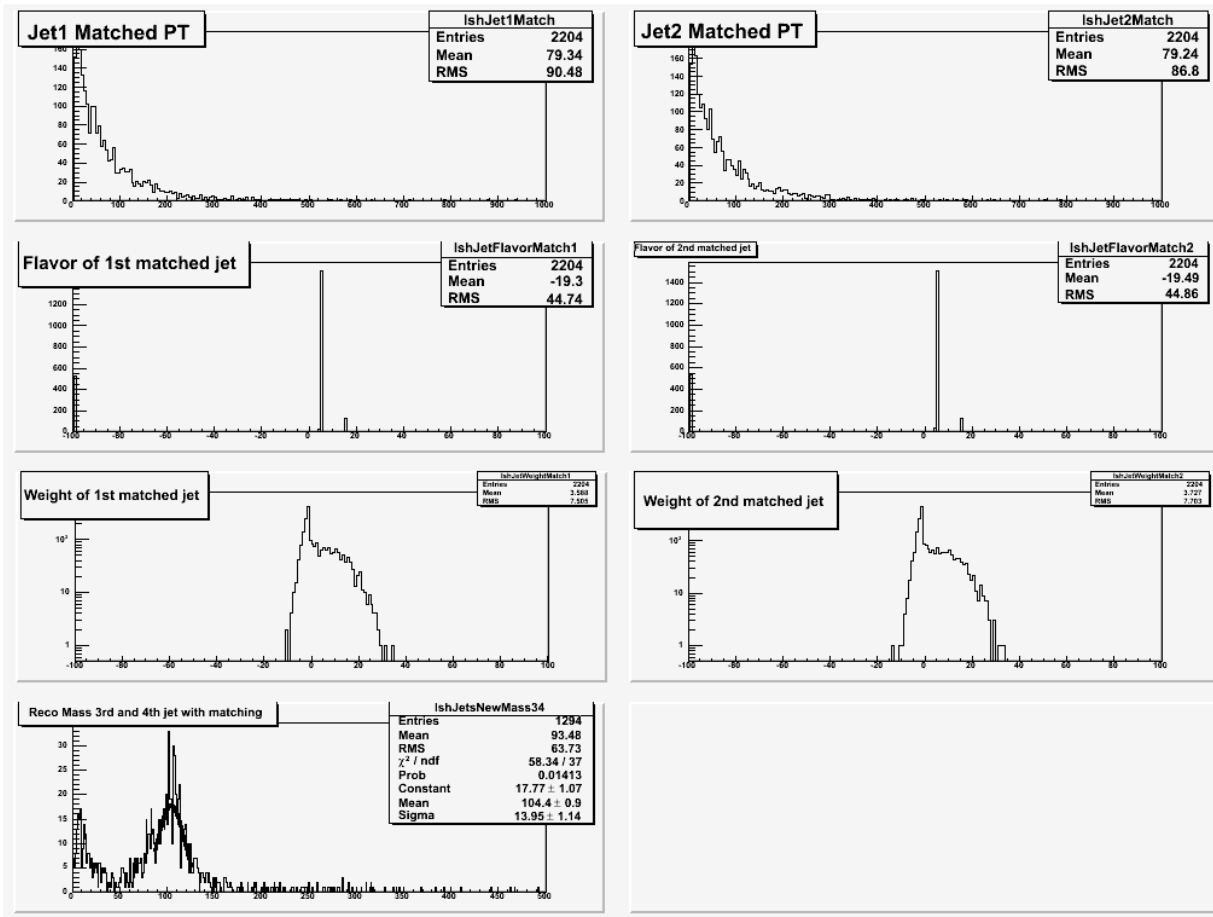
These are events where two jets are selected by pairing them with two b-partons.
The two jet inv mass is then reconstructed
Note the purity of the tag (flavor plot)

(these events are selected only using b-parton info and jets (antiKT): no trigger/jet multiplicity request)

Real Analysis

- Since we cannot use b-partons to pair our jets, we need now to select them through a weight cut

- Since we do have the flavor information (simulation!) we can check that we can achieve high purity

- in fact btag efficiency and rejection are calculated using truth info

- The weight used is the default one:
  - (*newJets_Akt)[j]->getFlavourTagWeight(); // weight for IP3DSV1

B-tagging performance estimators

- B-jet efficiency ε_b as function of weight cut:
 - Denominator:
    - jets defined as b using MC truth
      - with fixed p_T and η cuts (p_T > 25 GeV/c, $|\eta|$<2.5)
  - Numerator:
    - ditto + cut on a tagging weight
- Light-jet rejection R_u = 1 / ε_u
  - R=100 means 1% mistag rate
  - light jets: u, d, s, g
- B-jet efficiency as a function of P_T and η
  - Denominator:
    - jets defined as b using MC truth
      - with fixed cut on weight (SV1 > 3, LHSig > 0.9, …)
  - Numerator:
    - ditto + cut on p_T and η

Jets 3 and 4 and reco dijet mass before b-tag
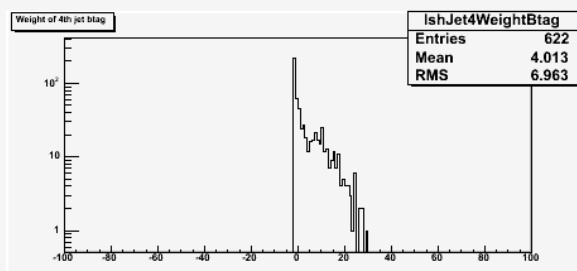

SIGNAL
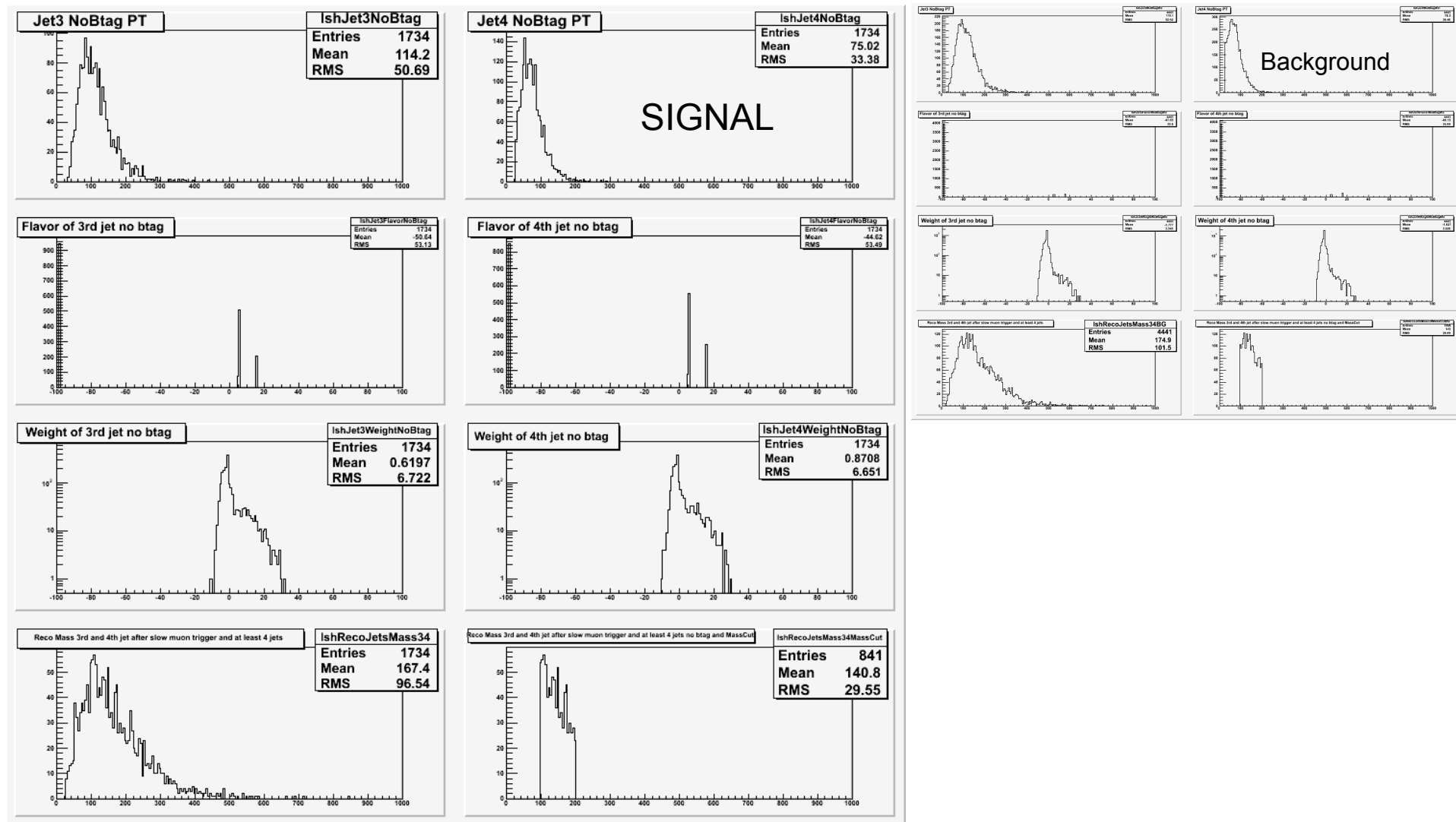
Background

Jet 3 and 4 with btag cut (-3)

Signal
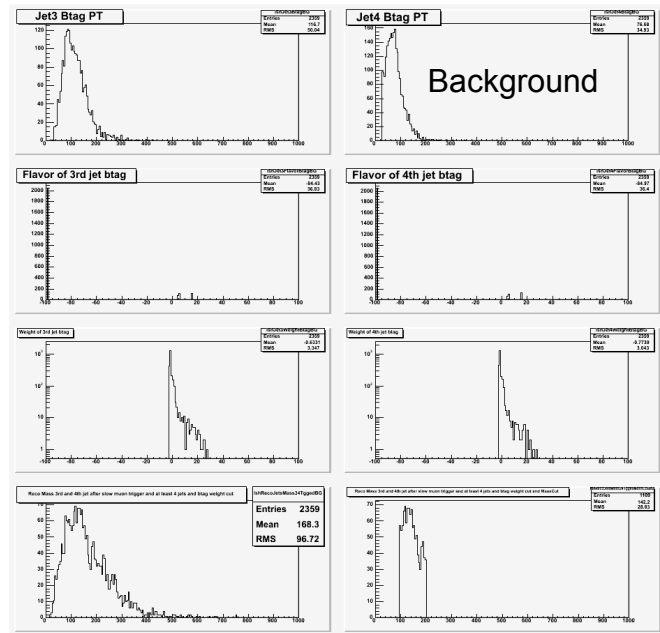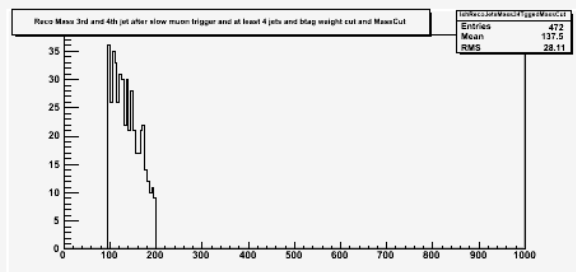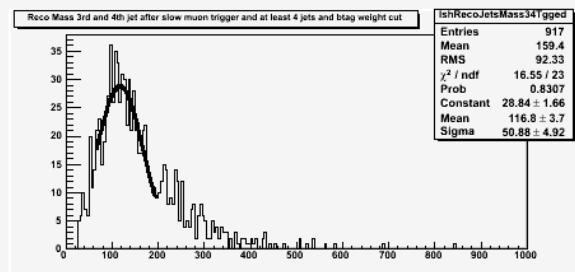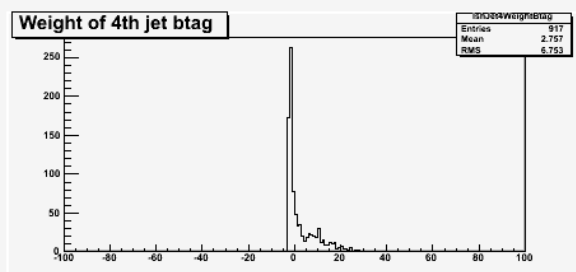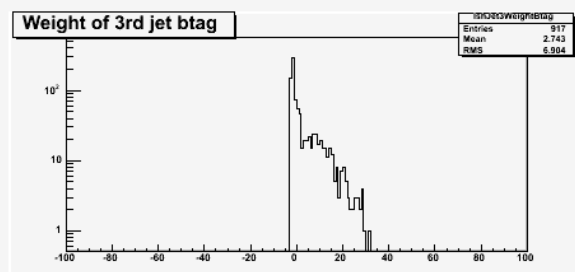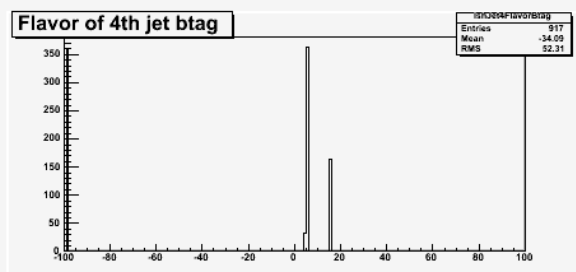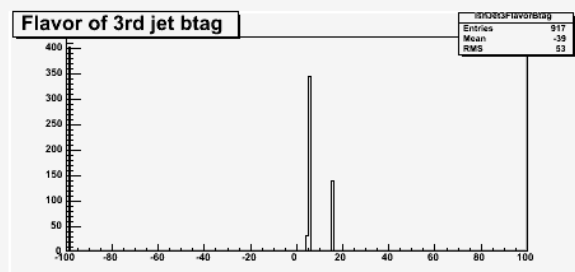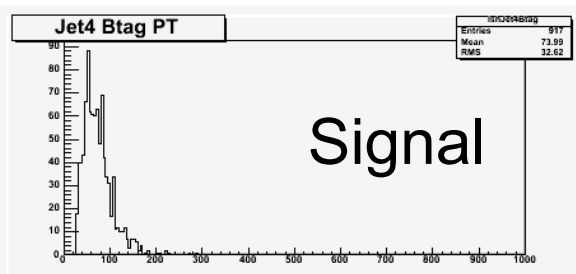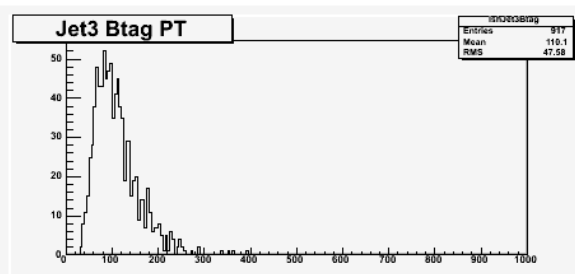
Background

Jet 3 and 4 with btag cut (-2)

Jet 3 and 4 with btag cut (-1)

Signal
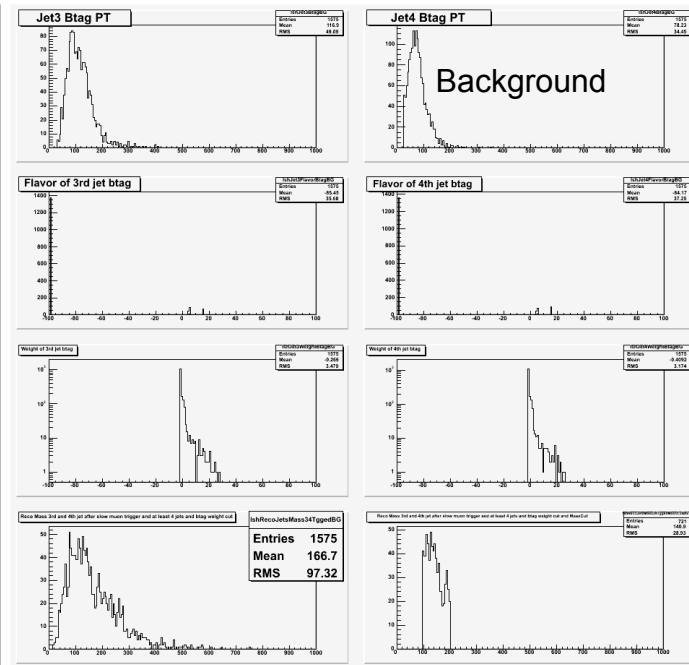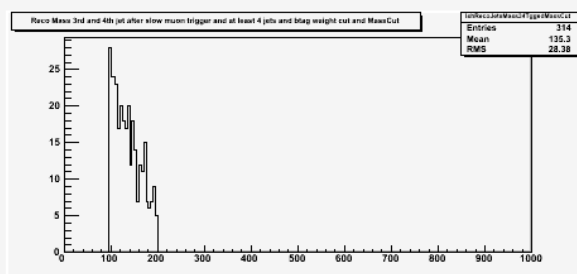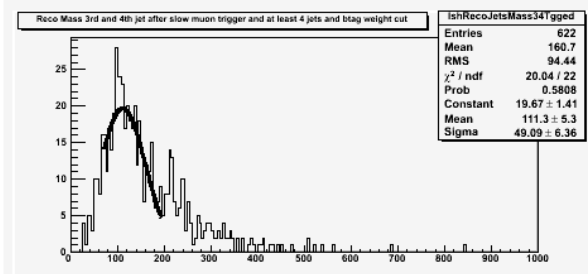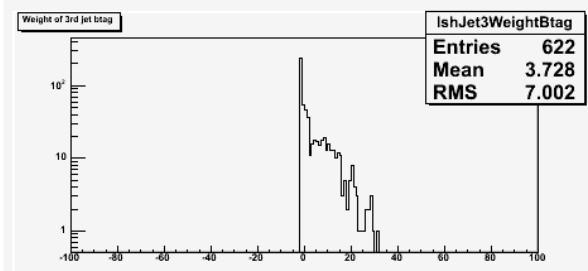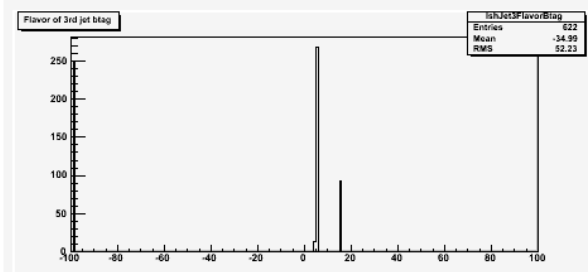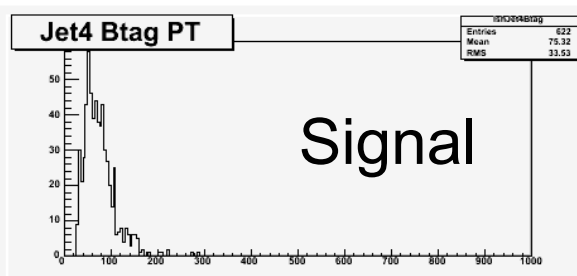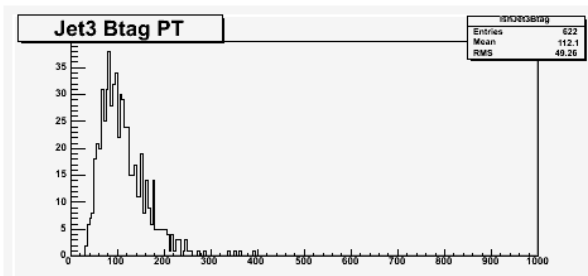
Background

Jet 3 and 4 with btag cut (0)

Signal
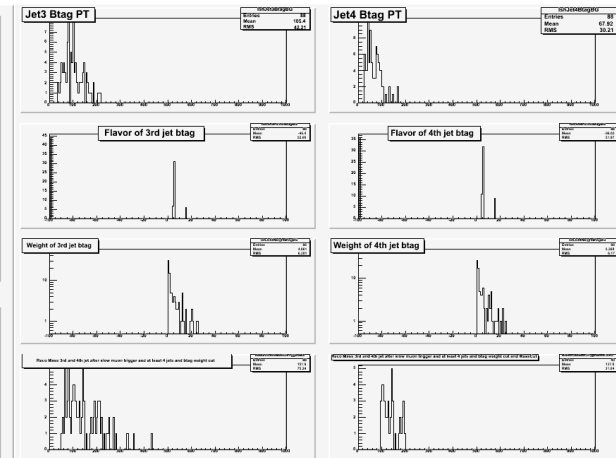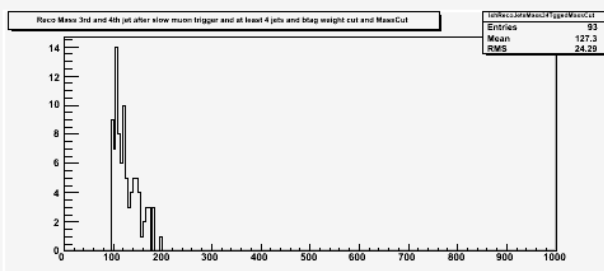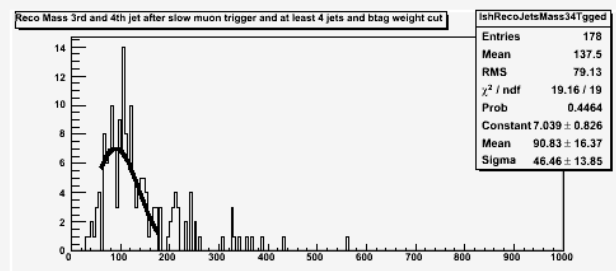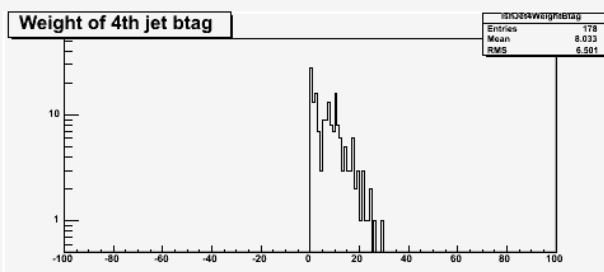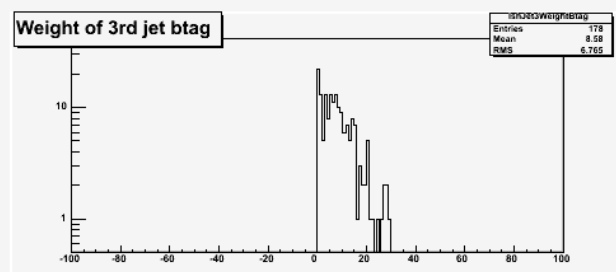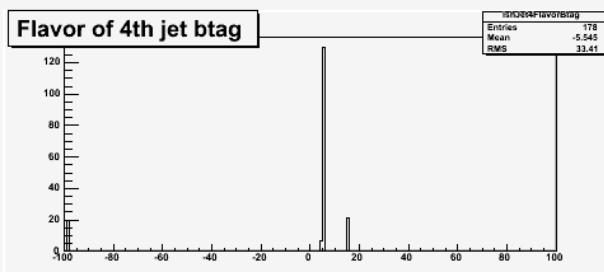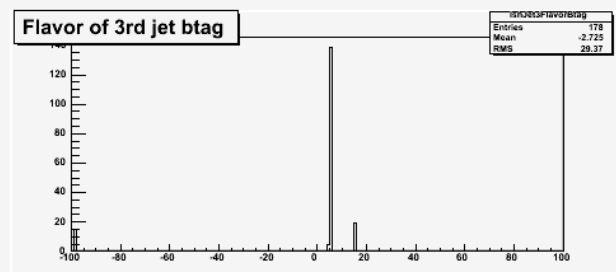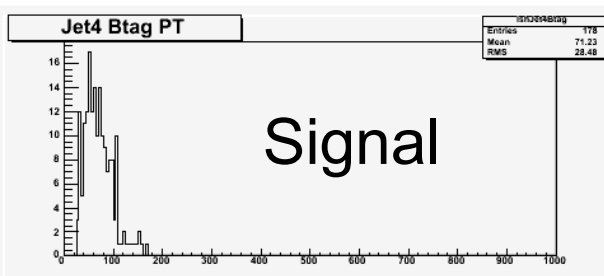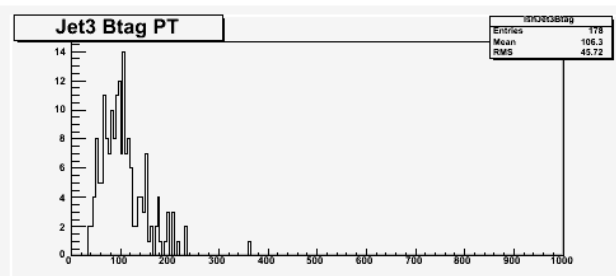
Background

Results:

Weight cut > -3

```
=======ANALYSIS CUTS    =====================================
 Number of events with one slepton trigger  1918
 Number of events with one slepton trigger  and 6 jets  1840
 Number of events with one slepton trigger  and 6 jets with cuts 1734
 Number of events with one slepton trigger  and 6 jets with cuts and btag weight greater than -3  917
 Number of events with one slepton trigger  and 4 jets with cuts and btag weight greater than -3 and dijet mass between 95 and 200 472
 =======Background      =====================================
 Number of events w/o Higgs 7308
 Number of events with one slepton trigger  5670
 Number of events with one slepton trigger  and 6 jets  4956
 Number of events with one slepton trigger  and 6 jets with cuts 4196
 Number of events with one slepton trigger  and 6 jets with cuts and btag weight greater than -3  2359
 Number of events with one slepton trigger  and 6 jets with cuts and btag weight greater than -3 and dijet mass between 95 and 200
1109
```
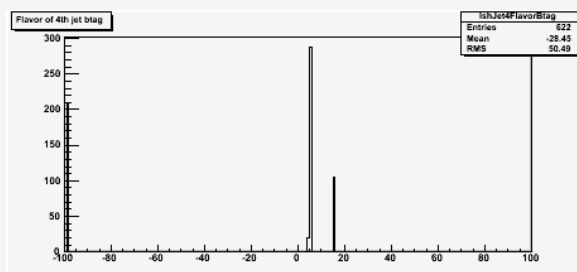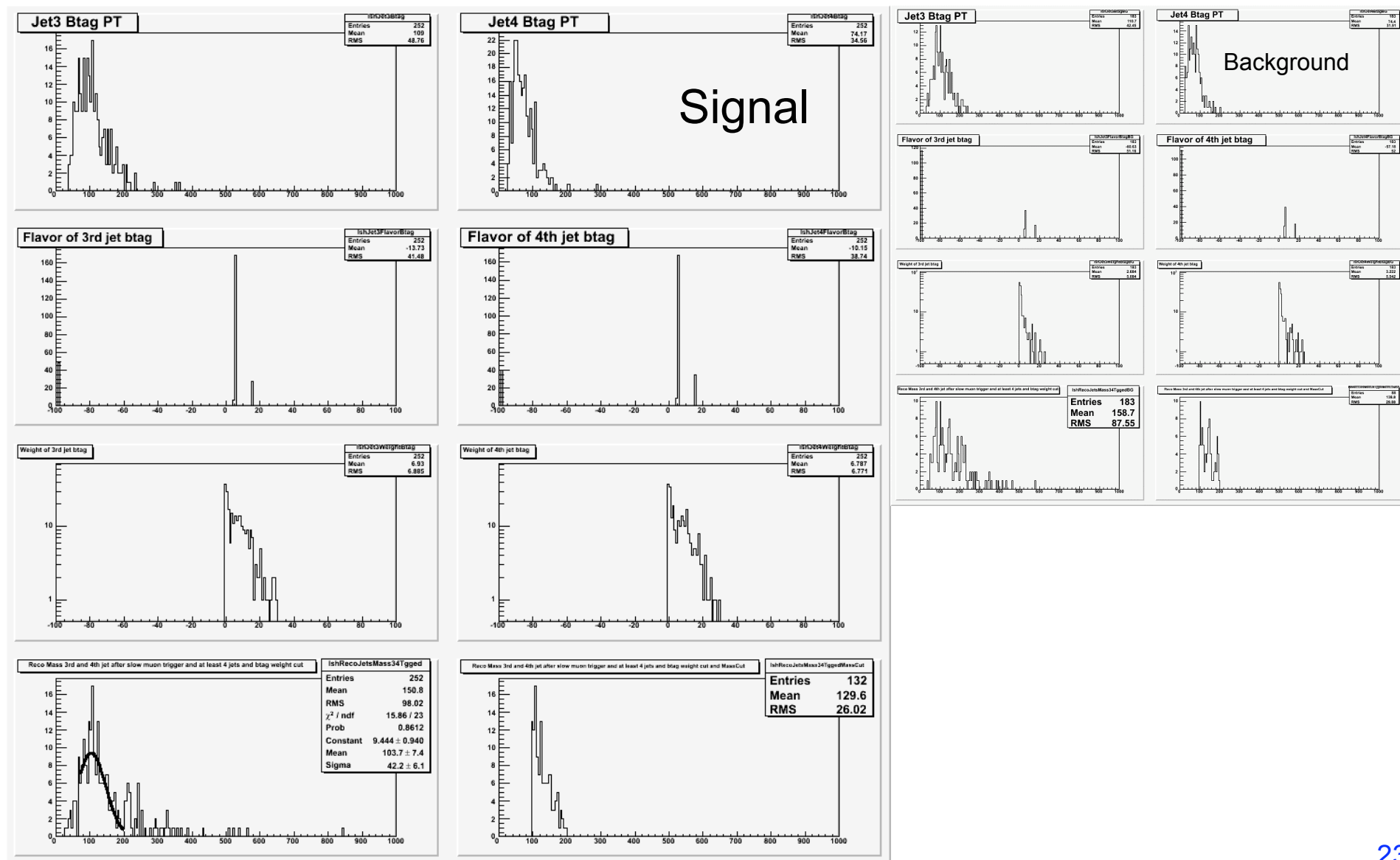
S/B=917/2359

925/2491

Weight cut > -2

Njet ≥ 5

```
=======ANALYSIS CUTS    =====================================
 Number of events with one slepton trigger  1918
 Number of events with one slepton trigger  and 6 jets  1840
 Number of events with one slepton trigger  and 6 jets with cuts 1734
 Number of events with one slepton trigger  and 6 jets with cuts and btag weight greater than -2  622
 Number of events with one slepton trigger  and 4 jets with cuts and btag weight greater than -2 and dijet mass between 95 and 200 314
 =======Background      =====================================
 Number of events w/o Higgs 7308
 Number of events with one slepton trigger  5670
 Number of events with one slepton trigger  and 6 jets  4956
 Number of events with one slepton trigger  and 6 jets with cuts 4196
 Number of events with one slepton trigger  and 6 jets with cuts and btag weight greater than -2  1575
 Number of events with one slepton trigger  and 6 jets with cuts and btag weight greater than -2 and dijet mass between 95 and 200 721
```

S/B = 622/1575

629/1672

Results:

Weight cut > -1

```
=======ANALYSIS CUTS    =======================================
 Number of events with one slepton trigger  1918
 Number of events with one slepton trigger  and 6 jets  1840
 Number of events with one slepton trigger  and 6 jets with cuts 1734
 Number of events with one slepton trigger  and 6 jets with cuts and btag weight greater than -1  252
 Number of events with one slepton trigger  and 4 jets with cuts and btag weight greater than -1 and dijet mass between 95 and 200 132
 =======Background       =======================================
 Number of events w/o Higgs 7308
 Number of events with one slepton trigger  5670
 Number of events with one slepton trigger  and 6 jets  4956
 Number of events with one slepton trigger  and 6 jets with cuts 4196
 Number of events with one slepton trigger  and 6 jets with cuts and btag weight greater than -1  183
 Number of events with one slepton trigger  and 6 jets with cuts and btag weight greater than -1 and dijet mass between 95 and 200 88
```

S/B = 252/183

194/254

Weight cut > 0

```
=======ANALYSIS CUTS    =======================================
 Number of events with one slepton trigger  1918
 Number of events with one slepton trigger  and 6  jets  1840
 Number of events with one slepton trigger  and 6 jets with cuts 1734
 Number of events with one slepton trigger  and 6 jets with cuts and btag weight greater than 0  178
 Number of events with one slepton trigger  and 6 jets with cuts and btag weight greater than 0 and dijet mass between 95 and 200 93
 =======Background       =======================================
 Number of events w/o Higgs 7308
 Number of events with one slepton trigger  5670
 Number of events with one slepton trigger  and 6 jets  4956
 Number of events with one slepton trigger  and 6 jets with cuts 4196
 Number of events with one slepton trigger  and 6 jets with cuts and btag weight greater than 0  88
 Number of events with one slepton trigger  and 6 jets with cuts and btag weight greater than 0 and dijet mass between 95 and 200 43
```

S/B = 178/88

180/91

How many events in 1fb^{-1}?

- Assuming a cross section of 240 fb for Higgs-only events and 1210 for bkgr:
  - Trigger: 80% (77.5)   192 937
  - ≥6 jets : 76% (67.8)   182 820
  - 6 jets with cuts : 72% (57.4)   172 694
  - 2 bjets: 10% (2.5)(cut Weight > -1) 24   30
  - 2 bjets: 8% (1.2)(cut Weight > 0)   19   14

Btagging efficiency and Rejection factors

Weight Cut	W > -3	W > -2	W > -1	W > 0
ε(b)	81%	76%	71%	63%
Mistag rate	40-55%	22-36%	3%	1.2%

```
if (jetET[2] > 25 && jetET[3] > 25 && fabs(jetEta[2]) < 2.5 && fabs(jetEta[3]) < 2.5) {

    if ( fabs(jetFlavor[2]) == 5 && fabs(jetFlavor[3]) == 5) {
            bTagDenominator++;
            if (jetWeight[2] > weightCut && jetWeight[3] > weightCut) bTagNumerator++;
    }// if ( fabs(jetFlavor[2]) == 5 && fabs(jetFlavor[3]) == 5)

    if ( fabs(jetFlavor[2]) != 5 && fabs(jetFlavor[3]) != 5) {
            RTagDenominator++;
            if (jetWeight[2] > weightCut && jetWeight[3] > weightCut) RTagNumerator++;
    }// if ( fabs(jetFlavor[2]) != 5 && fabs(jetFlavor[3]) != 5)

} // if (jetET[2] > 25 && jetET[3] > 25 && fabs(jetEta[2]) < 2.5 && fabs(jetEta[3]) < 2.5)
```

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Efficiency vs Eta and PT

```
for ( int f = 0 ; f < 20 ; f++) {
    if (jetFlavor[3] == 5  && fabs(jetEta[3]) < 2.5 && ( jetET[3] >= 25+10*f &&  jetET[3] < 25 +10*(f+1)  ) ){
        bTagEffPTDenominator3[f]++;
        if (jetWeight[3] > weightCut) bTagEffPTNumerator3[f]++;
    }// if (jetFlavor == 5  && fabs(jetEta[3]) < 2.5 && ( jetET[3] >= 25+10*f &&  jetET[3] < 25 +10*(f+1)  ) ){
} // for ( int = 0 ; f < 20 ; f++)
for (int f = 0; f < 10; f++) {
    if (jetFlavor[3] == 5 && jetET[3] > 25 && (jetEta[3] >= -2.5 + 0.5*f && jetEta[3] < -2.5+0.5*(f+1)) ) {
        bTagEffEtaDenominator3[f]++;
        if (jetWeight[3] > weightCut)bTagEffEtaNumerator3[f]++;
    } // if (jetFlavor == 5 && jetET[3] > 25 && (jetEta[3] >= -2.5 + 0.5*f && jetEta[3] < -2.5+0.5*(f+1)) )
}// for (int f = 0; f < 10; f++)
```

Fluctuations due to low statistics

LeptoSusy Higgs
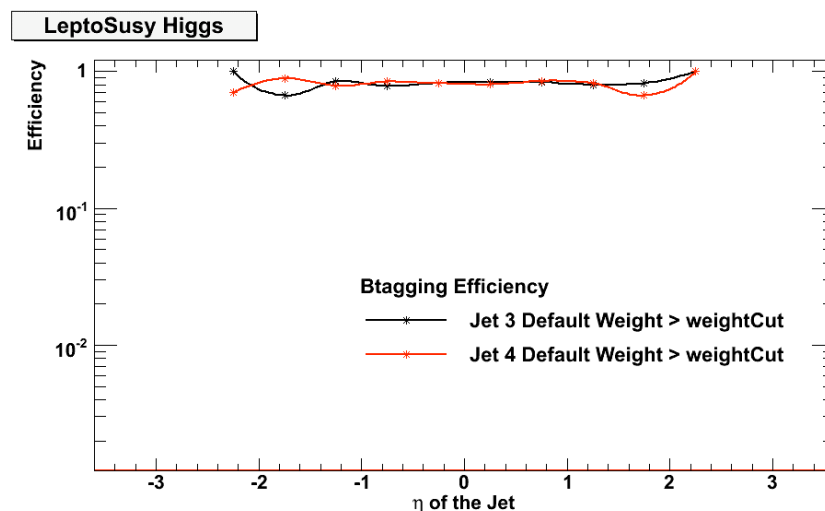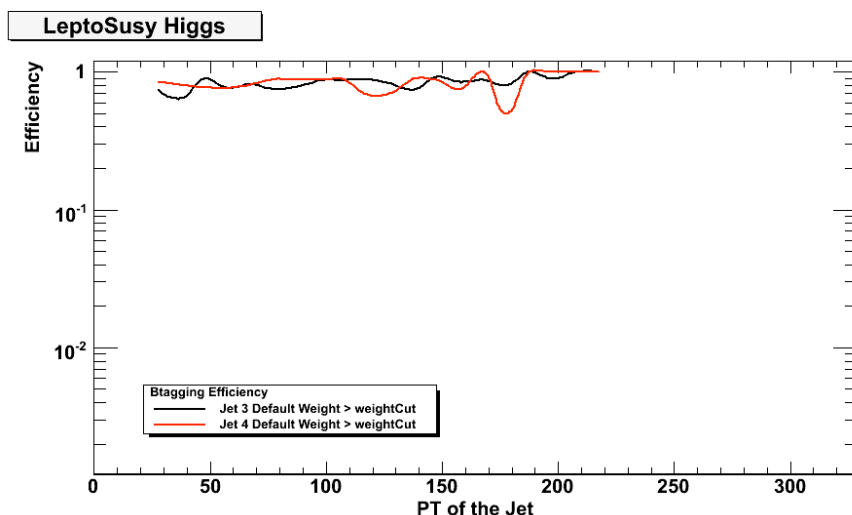
Eta = -2.25 == Efficiency Jet 3= 1
Eta = -2.25 == Efficiency Jet 4= 0.7
Eta = -1.75 == Efficiency Jet 3= 0.666667
Eta = -1.75 == Efficiency Jet 4= 0.894737
Eta = -1.25 == Efficiency Jet 3= 0.846154
Eta = -1.25 == Efficiency Jet 4= 0.782609
Eta = -0.75 == Efficiency Jet 3= 0.78481
Eta = -0.75 == Efficiency Jet 4= 0.844444
Eta = -0.25 == Efficiency Jet 3= 0.825
Eta = -0.25 == Efficiency Jet 4= 0.820755

Eta = 0.25 == Efficiency Jet 3= 0.836538
Eta = 0.25 == Efficiency Jet 4= 0.803571
Eta = 0.75 == Efficiency Jet 3= 0.838384
Eta = 0.75 == Efficiency Jet 4= 0.854167
Eta = 1.25 == Efficiency Jet 3= 0.8
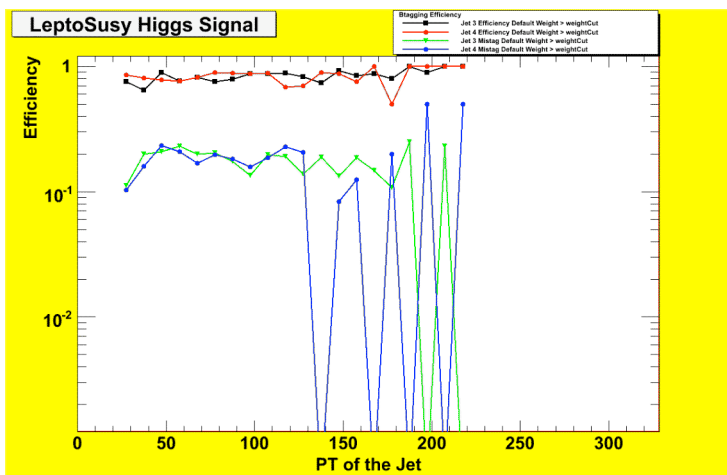Eta = 1.25 == Efficiency Jet 4= 0.821429
Eta = 1.75 == Efficiency Jet 3= 0.823529
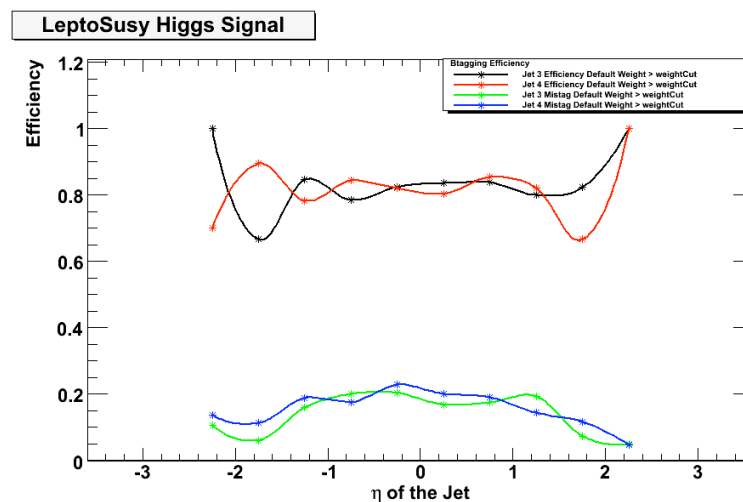Eta = 1.75 == Efficiency Jet 4= 0.666667
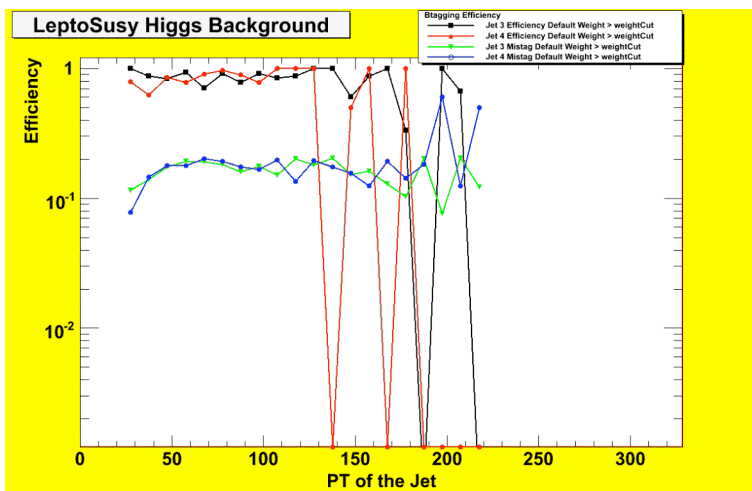Eta = 2.25 == Efficiency Jet 3= 1
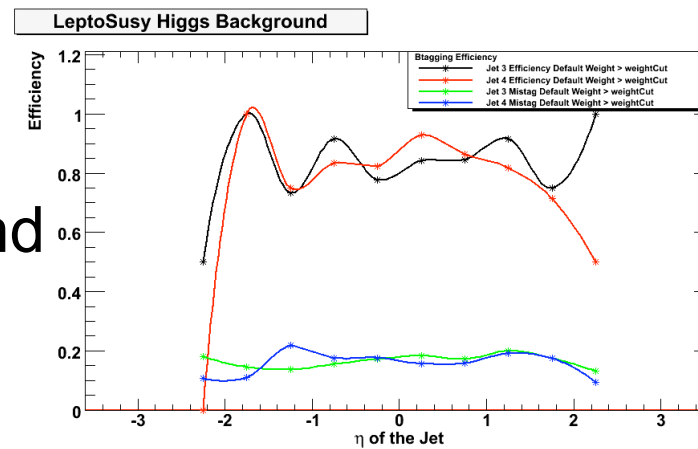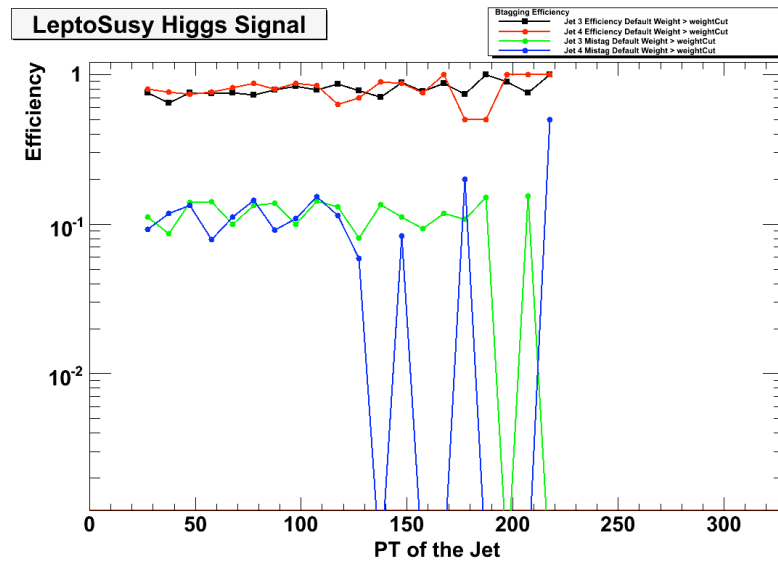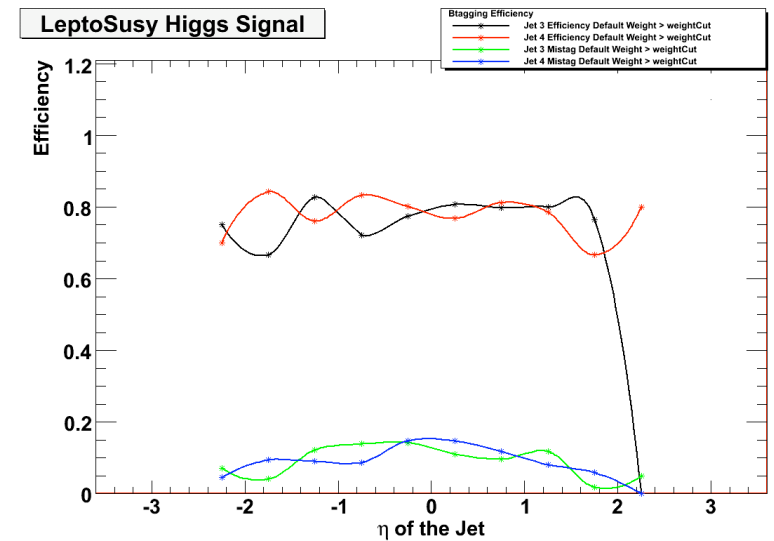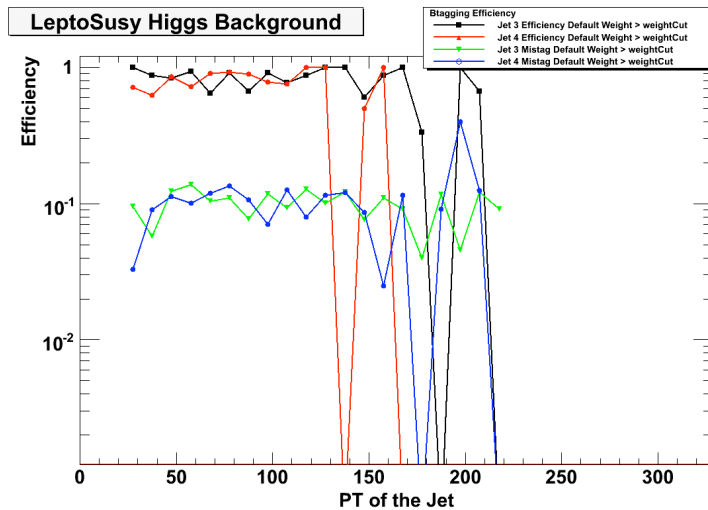Eta = 2.25 == Efficiency Jet 4= 1

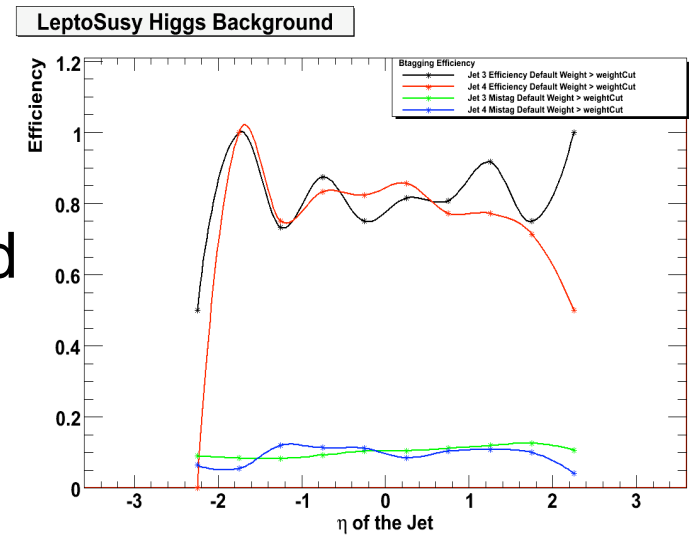# Efficiency and Mistag

Signal

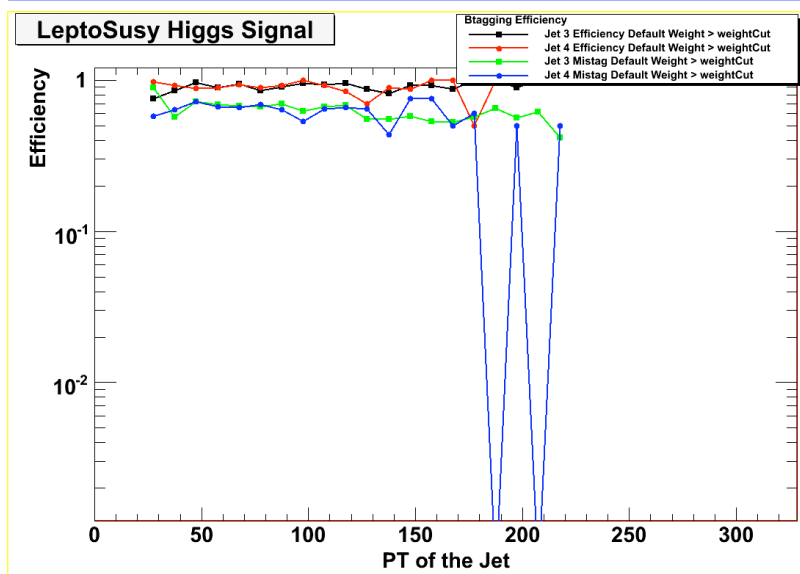Weight > -1

Background

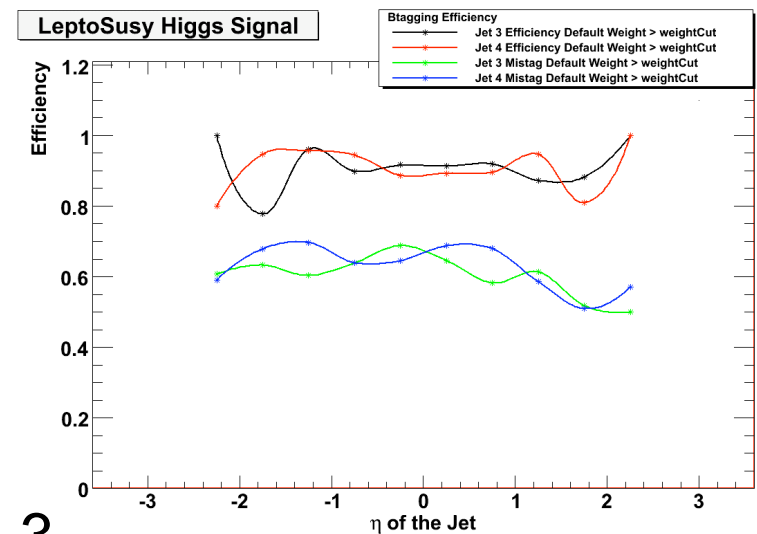# Efficiency and Mistags
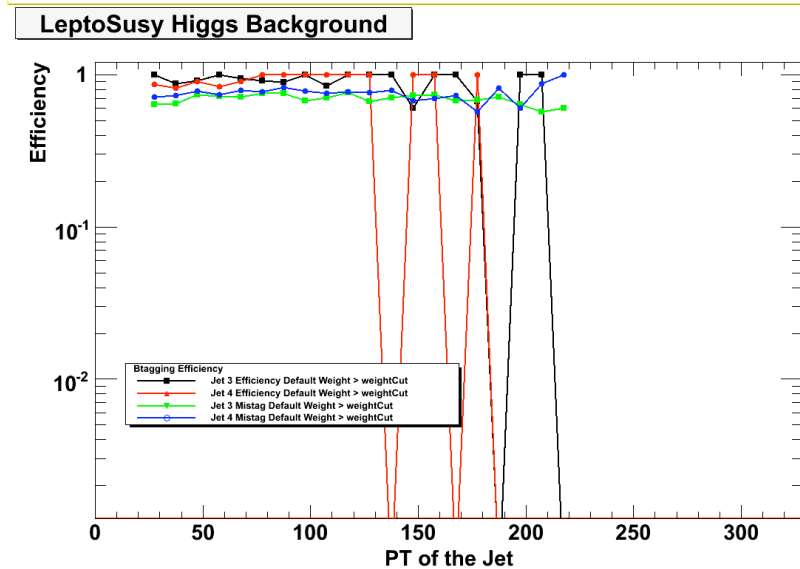

Signal

Weight > 0

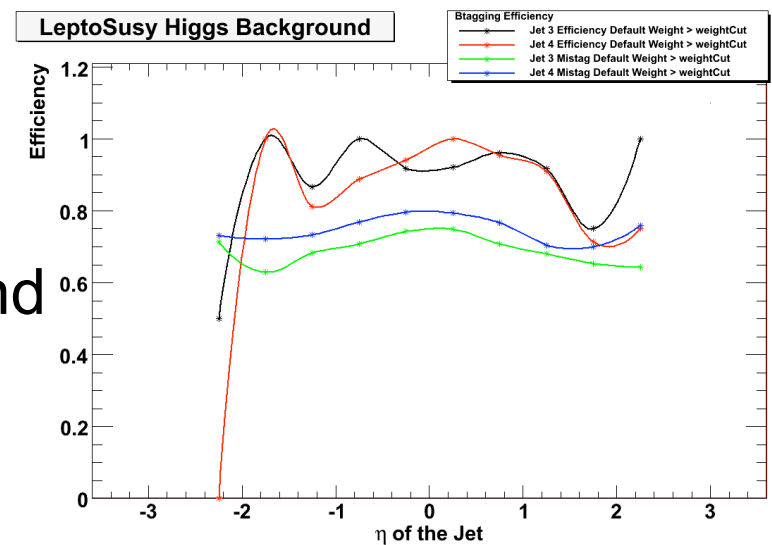Background

Efficiency and Mistags

Signal

Weight > -3

Background

Simona Rolli

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To Do: meant to be a do list for all

- Btagging efficiency as function of PT and eta
  - Investigate other taggers?
    - Might need to reprocess the sample…
- Lepton multiplicities
  - Cleanup of electrons and muons
  - Even if no lepton selection is done…
    - Maybe add to the selection criteria: 1 slow muons (trigger), a second slow muon and no more than 2 leptons? + jets and b-tag?
      - Investigate….
- Trigger Efficiency:
  - Number of events passing slow muon trigger / number of events with offline slow muon
    - Need to add trigger branch to ntuple (for now only l2pass_mu20Slow)
- InvMass searches code (Argonne)
  - Need to implement the slow muon recognition
  - Possible base for a signature based analysis?
- Start writing a draft note
- AOB….

L2_mu20_slow

S. Bressler, S. Tarem, S. Vallecorsa

- mu20_slow is part of the physics menu

- It has been specifically designed to trigger on heavy long lived charged particles

- It modifies standard muon triggers to measure β
  - Recover the cases in which no inner detector track is associated to muon spectrometer hits
    - low β candidates or charge flipping R-Hadrons
  - Improve efficiency for low β in EF

- It has very low bkgd rates at 10^{31} and 10^{34}

- It can be activated as soon as RPC and MDT timing are well calibrated
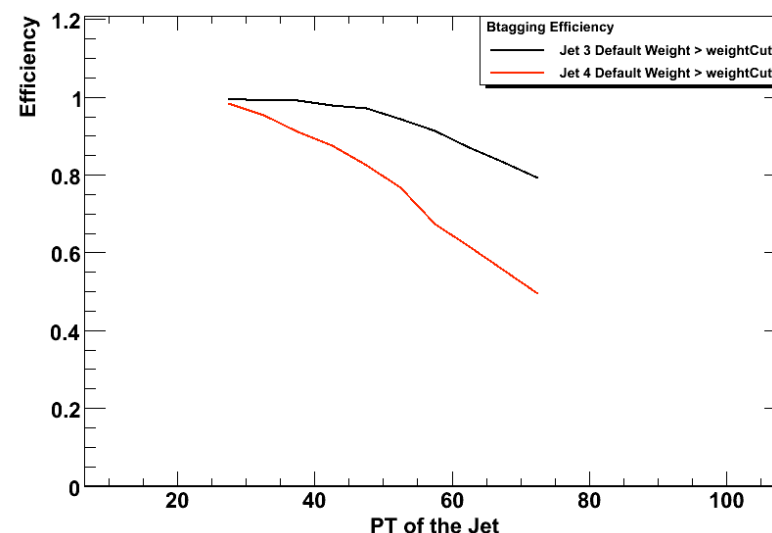
Efficiency vs Eta and PT
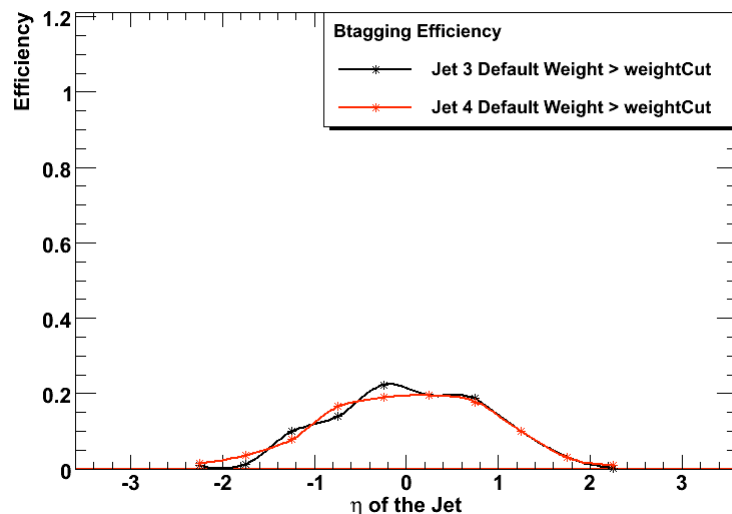
Weight > -1

The plots are normalized to jet with Weight Cut, eta/PT cut and flavor == 5
Nothing changes much…

```
if (jetWeight[2] >weightCut   && fabs(jetEta[2]) < 2.5 ) {
 for (int f = 0 ; f < 10 ; f++) {
   if (fabs(jetFlavor[2]) == 5) {
      bTagEffPTDenominator[f]++;
         if ( jetET[2] > 25+5*f   ) bTagEffPTNumerator[f]++; // cumulative!
   } // for (int f = 0 ; f < 10 ; f++)
 } //  if (fabs(jetFlavor[2]) == 5)
} // if (jetWeight[2] >weightCut  && jetWeight[3] > weightCut && fabs(jetEta[2]) < 2.5 && fabs(jetEta[3]) < 2.5)
```
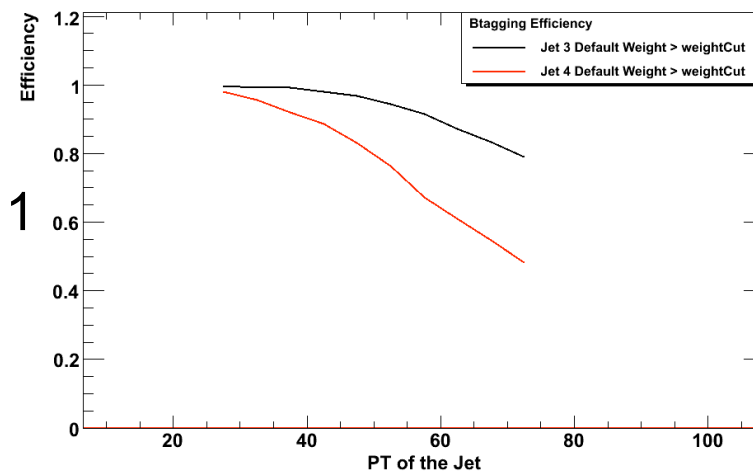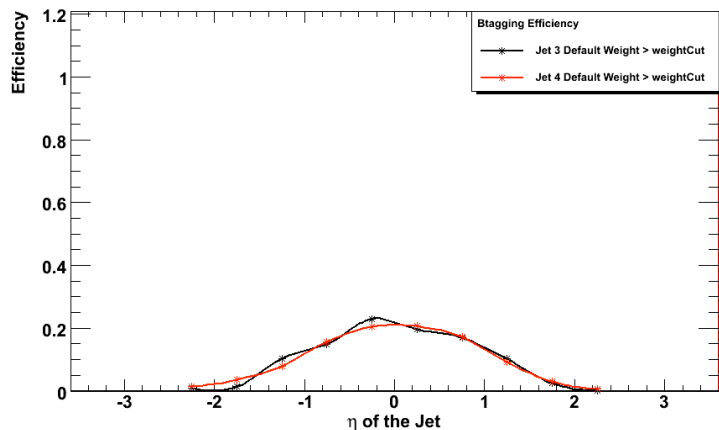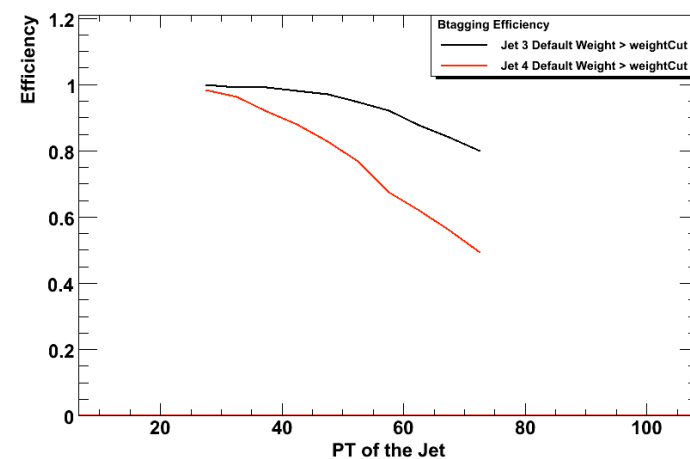
Efficiency vs Eta and Pt
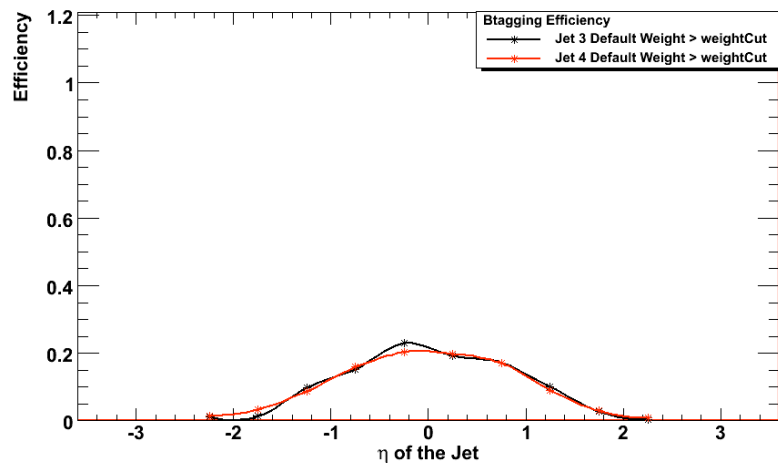
Weight > - 1

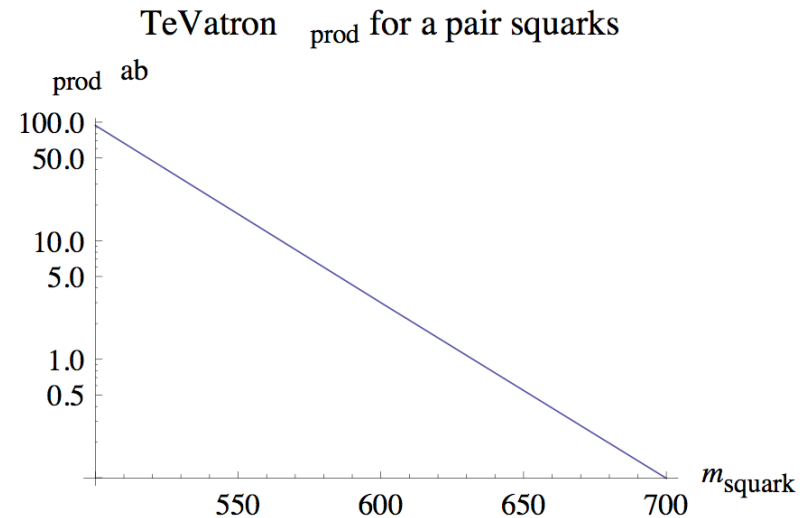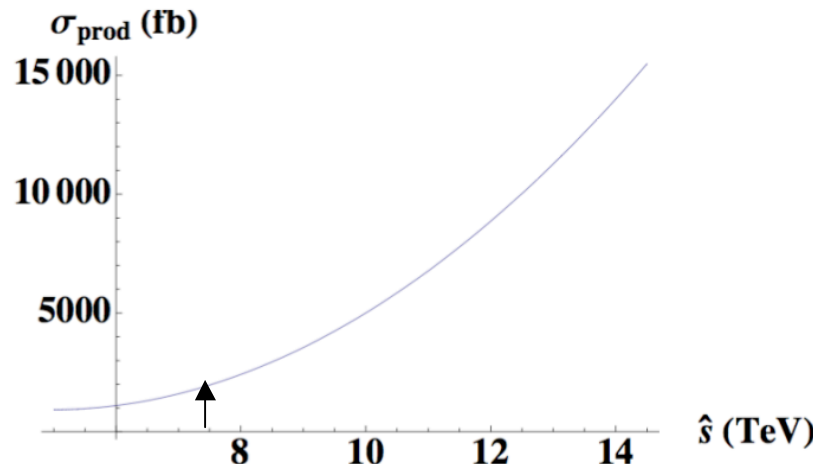These plots are normalized to jet with weight cut and PT/eta, but not flavor!

Weight > 0

Cross Section:LHC vs Tevatron

- 1) 7 TeV pp
  - Production cross section: 1.45 pb (240fb for Higgs).
    - q-q initial state is 70%, q-antiq is 20% and g-g is 10%.
- 2) 2 TeV ppbar
  - Production cross section is 159.8 ab (attobarns)
    - q-anti q is 159.5 ab (99%).